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A Collaborative Plan for Improving NCEP Operational and NASA Research Satellite Data Assimilation Systems

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Introduction

In recent years, assimilation of satellite data in operational Numerical Weather Prediction (NWP) systems has made great strides. For example, significant forecast improvements have resulted from the 1995 NCEP implemention of the direct assimilation of NESDIS TOVS cloud cleared radiances and subsequent enhancements. More recently, NCEP, with substantial assistance from NESDIS, implemented NOAA-15 AMSU-A data in March 1999, within one year of launch of NOAA-15. Impacts of AMSU-A data were distinctly positive in both the Northern and Southern Hemispheres. NASA/DAO has made detailed impact studies of operational and future scatterometer data which were well validated by the short-lived NSCAT instrument and which provided strong motivation for the Quikscat replacement and for increased use of scatterometer in operational NWP..

Today, there is an even greater need for U. S. Agencies to collaborate toward improved and wider use of satellite data. More instruments will be launched in the next 5 years, such as Quikscat, AIRS and IASI. Furthermore, with the advent of more sophisticated land surface and prognostic water parameterizations in operational NWP models, there are now new opportunities for more complete use of current information from satellites in NWP, especially for radiometric data over land.

NCEP, NESDIS and NASA each have unique expertise to devote to improved satellite data assimilation and are willing to commit significant efforts toward this goal. This document provides lists of important projects that will result in greater and improved use of satellite data. Some projects are direct extensions of recent development and can begin immediately; the remainder can begin within several months or are ongoing. Most projects can be brought to an initial state of completion, defined by code running in a routine (operational or research) mode with at least neutral forecast impact, within 1-2 years. While it may not be possible to begin all projects on this list immediately, it is expected that all of them can be brought to the initial completion stage within 5 years. For each project, a short statement of the intended goal, a description of important subtasks and a list of contributing personnel (with percentages of time committed to the project) from each organization are given below. A project leader is also listed. Progress on each project will be brought to management attention and a semi-annual review will be held.

The end result for these projects is computer code of sufficient flexibility and modularity that it can be incorporated into both operational and research data assimilation systems. As such, **this plan will provide technology transfer** in the form of an expanding "toolbox" for scientists interested in data assimilation development. Creating such a toolbox is a necessary condition for building a community infrastructure for data assimilation. Since many types of data are involved in these projects, the issue of standards for data ingest will be considered under this plan. These standards, together with an improved code modularity, will enable more portability and accessability for the scientific community.

NCEP, NESDIS and NASA personnel working on satellite data assimilation believe that pooling of their unique expertise will result in a more rational, efficient and rapid development of satellite data for NWP in the U. S. over the next 1-5 years. Both the research and operational forecast communities will benefit from this type of effort. This plan could be expanded to include other interested Offices, such as the Environmental Research Laboratories, if good progress is made on this initial plan.

Personnel Involved in Satellite Data Assimilation

Personnel who spend a significant percentage of their time on satellite data assimilation issues and their particular area of expertise are listed below in alphabetical order with their committed percent of effort in parentheses.

NCEP:

Larry Breaker: SST (?)
Dave Behringer: ocean data assimilation (?)
John Derber: global atmospheric data assimilation (50)
Bill Gemmill: SSM/I data, surface winds (50)
Pablo Grunmann: land surface adjoint model (?)
Vladimir Krasnopolsky: neural network retrievals for SSM/I (50)
Ying Lin: precipitation data (100)
Dag Lohmann: Assimilation of land surface data (?)
Curtis Marshall: Assimilation of land surface data (?)
Ken Mitchell: Assimilation of land surface data (?)
Dave Parrish: mesoscale atmospheric data assimilation (20)
Richard Reynolds: SST (100)
Jean Thiebaux: ocean data assimilation (??)
Russ Treadon: assimilation of precipitation data (85)
Wan-shu Wu: Ozone data assimilation, advanced 3D-VAR techniques (15)
Wainqu Wang: SST (100)
Tsann Yu: ocean surface winds (100)
Qing yun Zhao: Hurricane and clouds (20)
2 New NWS Hires (contractors): radiative transfer and data handling (100)

NESDIS:

Bob Aune: Cloud analysis
Paul Chang: Scatterometer data
Kevin Gallo: land surface
Mitch Goldberg: Advanced sounder
Garik Gutman: land surface
Andy Heidinger: Radiative aspects of clouds, liquid and ice water
Jim Jung: cloud analysis
Tom Kleespies: Fast radiative transfer, OPTRAN implementation
Larry McMillin: soundings, OPTRAN design
Tim Schmit: GOES radiances
Larry Stowe: SST aerosol correction
Dan Tarpley: Land surface data
Mike Weinreb: data calibration
Fuzong Weng: microwave radiative transfer
Jim Yoe: GPS Met.

NASA/UMBC:

Bob Atlas: Acting Head, Data Assimilation Office; scatterometer data, observing system impact experiments
Joanna Joiner: Assimilation of sounding data, radiative transfer
Arthur Hou: Assimilation of precipitation data
Paul Houser: land surface
Peter Lyster: Kalman filtering
Larrabee Strow: Fast radiative transfer

Satellite Data Assimilation Projects (In parenthesis the percentage of persons time committed to this project)

1. Assimilation of precipitation (Treadon (70), Lin (70), Weng, Hou)
   Project Leader: Treadon

   Goal: to assimilate precipitation estimates from the following instruments into global and/or regional forecast systems and thereby improve representation of the atmospheric initial conditions
   - SSM/I
   - GOES
   - TRMM
   - AMSU A/B

   Activities: develop assimilation techniques for optimum use of these data (NWS, NASA), including algorithm support (NESDIS) for direct use in operational and research data assimilation system (Joint), assignment of error levels (Joint), and quality control (Joint)

2. GOES winds (Derber (10), new NCEP hire 1 (50), Velden (??))
   Project Leader: Derber

   Goal: to evaluate the impact of GOES winds on operational weather forecasts with emphasis on tropical winds and hurricane forecasts.

   Activities: implement operational use of GOES visible winds and evaluate impact (NWS); transition to operational use of a standardized BUFR message for satellite-derived winds (NESDIS, NWS); develop, evaluate and implement improved quality control procedures (NWS, NESDIS) and improved assimilation techniques including better forward models for cloud track and clear air water vapor derived winds (NWS); investigate advanced assimilation techniques for direct use of imagery with 4D-VAR (NWS).

3. GOES-10 radiances (Derber (15); Parrish (20); Kleespies, Weinreb, Schmit)
   Project Leader: Weinreb

   Goal: to enable assimilation of GOES-10 radiances by accurate characterization of both GOES-10 and GOES-8 spectral response

   Activities: characterize bias in various channels of both GOES-10 and GOES-8 with sufficient accuracy to enable assimilation in NCEP global forecast system (NESDIS); assess impact; write journal article summarizing GOES impact results (NWS).

4. Maintenance and extend OPTRAN (Kleespies, McMillin, Van Delst, Joiner, Derber (10), NCEP New Hire 2 (50), Strow)
   Project Leader: McMillin

   Goal: construct a unified fast radiative transfer code suitable for both operational and research applications
   Activities: continue to improve accuracy and performance of operational OPTRAN code (NESDIS, NWS); extend OPTRAN to AIRS instrument (NESDIS, NASA); coordinate with Advanced Sounders project (below); test changes in operational and research data assimilation systems (NWS).

5. Quikscat (Chang, Yu (60), Gemmill (50), Atlas (25))
   Project Leader: Atlas

   Goal: evaluate Quikscat data and, if data prove of acceptable quality with reliable and timely delivery, implement operationally

   Activities: obtain early access to Quickscat “science” data and interface with operational and research analysis systems (NASA, NWS); evaluate data quality and forecast system performance over test period (NASA, NWS) ; establish operational (“fast delivery”) data access in BUFR format (NESDIS); interface with operational data assimilation system (NWS); compare science and fast-delivery data (Joint); perform pre-implementation testing (NWS); implement operationally (NWS).

6. NOAA Polar Orbiter backup (Treadon(5), NCEP new hire 1 (50), Derber (5), Goldberg ())
Project Leader: Derber

Goal: provide an operational backup for NOAA satellite data with DMSP data

Activities: provide DMSP data from SSM/T2, SSM/T and SSM/IS instruments operationally (NESDIS); evaluate the capability of DMSP data to backup NOAA satellite data (NWS); implement backup capability (NWS)

7. Satellite data over land (Tarpley, Mitchell (40), Gutman (), Lohmann (?),Marshall (?), Grunmann (?), Houser, Derber (5), Weng (), Kleespies ())
Project Leader: Tarpley

Goal: to improve the use of satellite sounding data over land and to use satellite-derived estimates of surface fluxes over land for improving initial specification of the land surface state for numerical forecast systems

Activities: develop improved emissivity models for microwave and IR over land/ice/snow (NESDIS); develop ultra-high resolution (4 km) vegetation/land/albedo use data sets (NESDIS); improve skin temperature prediction over land (NWS); provide satellite-derived surface insolation and skin temperature data (NESDIS); provide satellite-derived snow and soil moisture estimates (NESDIS, NASA); test and evaluate data and assimilation schemes (Joint).

8. Cloud and liquid water (Zhao (20), Treadon (15), Hou, Heidinger, Weng (), Jung (), Aune ())
Project leader: Treadon

Goal: to analyze satellite data for improved specification of initial conditions for cloud coverage and liquid and ice water content

Activities: examine and critically review algorithms for cloud coverage, and water and ice content from SSM/I, AMSU-B, AVHRR, SSMT/2, and GOES instruments (Joint); provide support for algorithms and develop quality control methods for analysis; use algorithms directly in operational and research data assimilation systems (NWS, NASA); evaluate forecast results (Joint); prepare for CloudSat (NWS, NESDIS, NASA??)

9. Improved SST analysis (higher time and space resolution) (Reynolds (100), W. Wang (100), Breaker (?), Gemmill (50), Stokes (30), Stowe, Wu ())
Project Leader: Reynolds

Goal: to improve SST analyses for both short-range and climate applications

Activities: review current SST analysis products and techniques and recent progress; determine future activities for improved SST analyses, including aerosol corrections

10. Neural network techniques for SSM/I and Quikscat products (Krasnopolsky (50), Yu (40), Gemmill (?))
Project Leader: Krasnopolsky

Goal: to improve use of SSM/I and Quikscat products in operational and research data assimilation systems

Activities: use neural network algorithm for SSM/I wind speeds directly in operational data analysis systems; evaluate results and implement if results warrant; apply neural network algorithm to Quikscat products and evaluate results

11. Advanced sounders: AIRS and IASI (Derber (5), NWS New Hire 2 (50), Joiner (), McMillin (), Goldberg (), Huang ())
Project Leader: Joiner

Goals: to prepare for AIRS, IASI and NPOESS advanced instrument data

Activities: review possible methods for data assimilation of kilochannel instruments (Joint); develop methods for incorporation, including extending OPTRAN for these instruments, into operational and research data assimilation systems (NASA, NWS); test methods with simulated data in OSSE framework (NWS, NASA); when data available, provide required data in timely manner for operational use (NESDIS, NASA);

12. GPS Met (Joiner, Wu (15), Yoe ())
Project Leader: Joiner

Goals: to build on current development efforts for using GPS data in operational and research data assimilation systems

Activities: review current efforts (Joint); convert GPS code to IBM supercomputer (NWS), develop methods which are sufficiently accurate, efficient and timely for operational data assimilation systems (Joint)

13. Observing System Simulation Experiments for Advanced Instruments (Lord (5), Masutani (100), Atlas (5), Kleespies, Yoe (), Aune ())
Project Leader: Lord

Goals: to investigate the estimated forecast impact of advanced (NPOESS) instruments, including a Wind Lidar and Advanced Sounders (see 11 above), and a GOES interferometer.

Activities: construct simulated conventional and advanced instrument data with appropriate error levels (Joint); evaluate performance of current observing system (NWS); evaluate performance of OSSE system with simulated current observing system (NWS, NASA); interface advanced instruments with current data assimilation system (NWS); perform OSSEs (NWS, NASA)